Mars Exploration Program (MEP) Program Update

Presented to:

Planetary Protection Subcommittee

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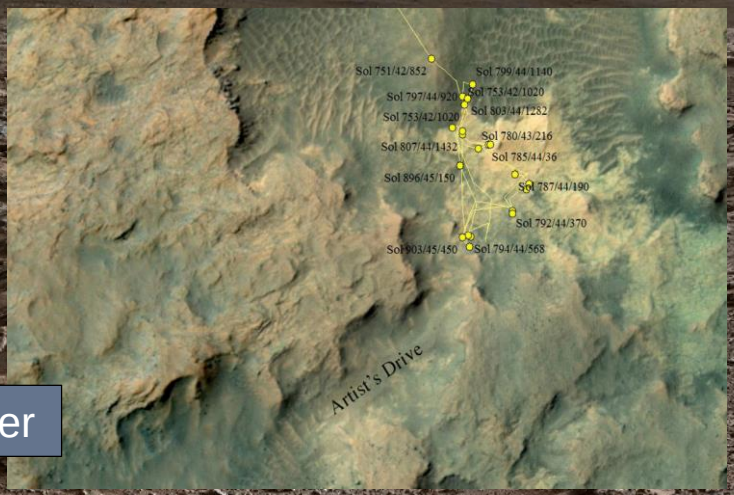
June 9, 2015

MEP Highlights at Mars

MAVEN probing Martian atmosphere

MRO HiRISE Imagery
locates the Beagle-2 Lander

OPPORTUNITY
a record run! *42.195 km*
(time 11 yrs 2 months)



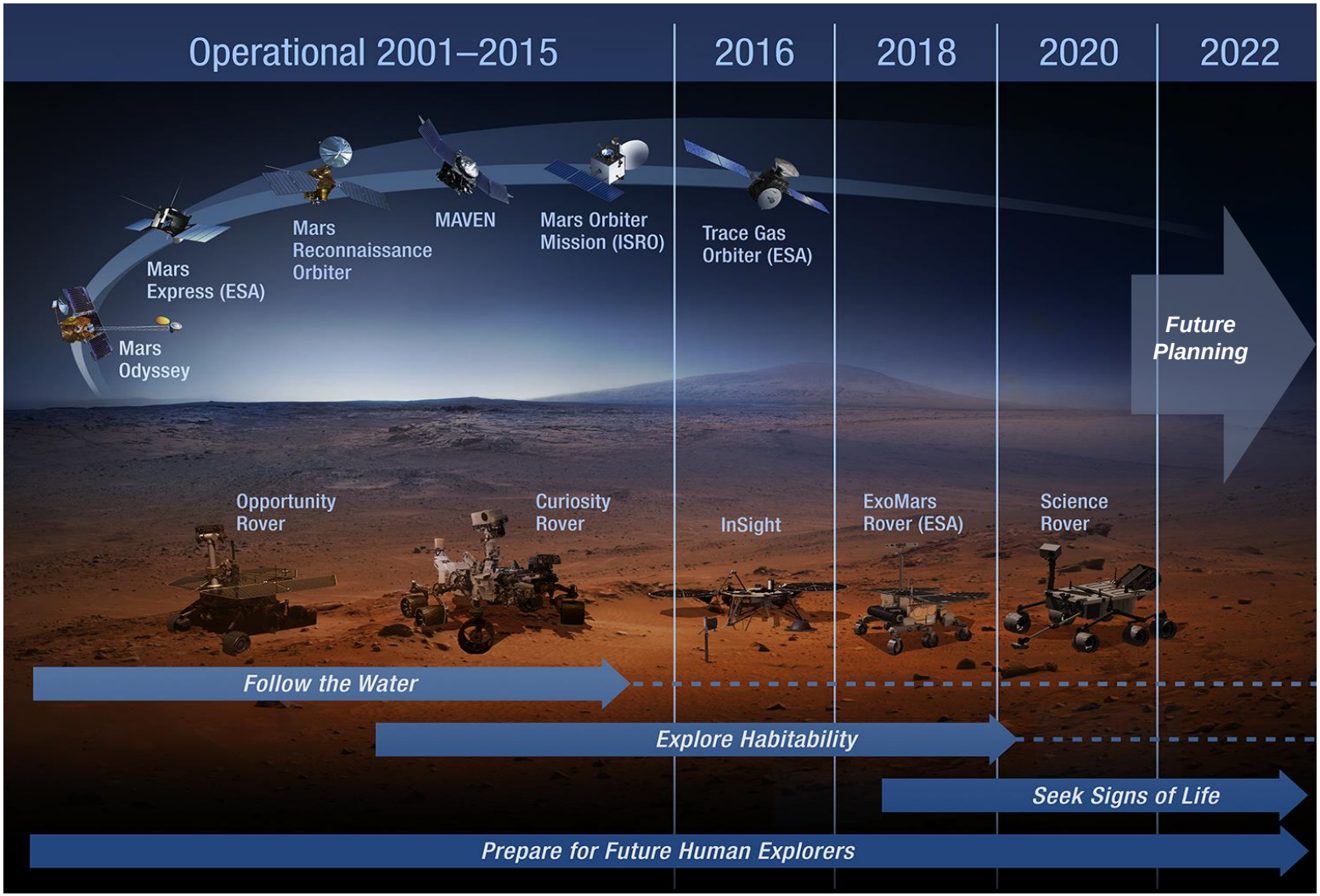
CURIOSITY exploring Gale Crater

Introduction

- **MEP is healthy and improving**
  - Operational assets continue to return remarkable science
  - Mars 2020 development proceeding well
  - MOMA-MS, a NASA partnered contribution for the 2018 ExoMars Lander, is in flight fabrication and assembly

- **Future mission planning underway**
  - NRC Decadal Survey science priorities continue to provide a foundation for future planning
  - Growing recognition that the science guided pathways of the MEP provide natural precursor capability for Human Exploration needs
  - Exploring and defining Science/Exploration synergies to advance next step priorities
    - MEP/HEOMD/STMD collaboration on Mars precursors
  - Begun studies and assessment of options to identify goals, objectives, and needs
    - MEP trade studies
    - Joint MEP/HEOMD/STMD trade studies
    - MEP/HEOMD co-chartered MEPAG SAG activities

Mars Exploration in This Decade



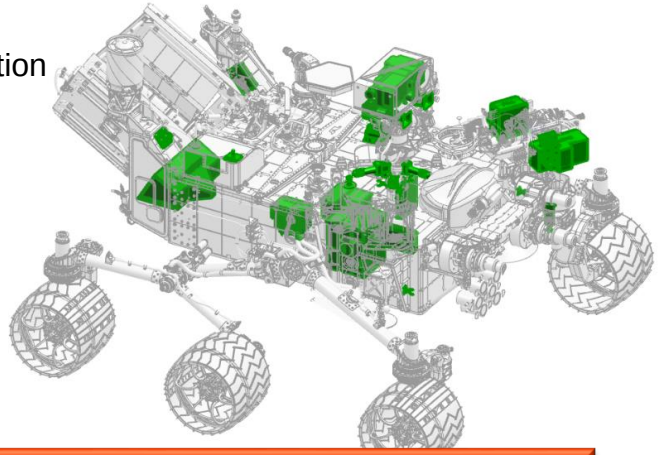
Mars 2020 Update

- Baseline Mars 2020 mission addresses the highest priority science
  - Builds on Curiosity results by investigating a landing site for possible bio-signature preservation in full geologic context
  - Provides HEOMD/STMD contributions to address key Strategic Knowledge Gaps
  - Provides cached samples for possible return

- **Completed Phase A and formally entered Phase B of formulation**
  - Completed instrument accommodation reviews, including implementing design modifications required at selection
  - SRB reported: *"Project is more mature than most in Phase A, ready for KDP-B decision milestone and Phase B start."*
  - Approved for Phase B by Agency Program Management Council (APMC) on May 20
  - High-heritage approach is providing stable foundation for Mars 2020. Heritage hardware (~90% of the flight system by mass) is essentially in Phase C/D. Parts buys and procurements for items with low risk of change are proceeding at a fast pace

- Published environmental impact statement and issued Record of Decision to baseline radioisotope power system, thus completing compliance with National Environmental Policy Act (NEPA)

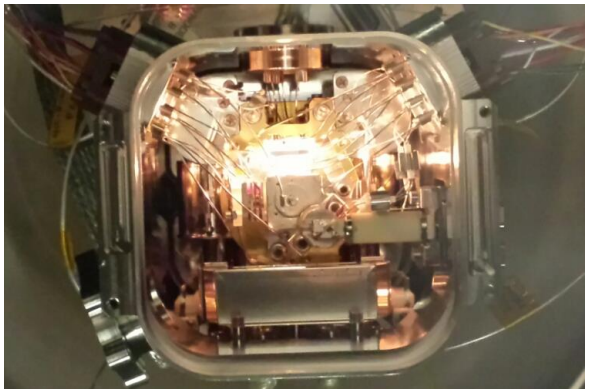
- Working detailed engineering and design trades for cache system implementation
- Rover systems / Payload Update:
  - Agreement reached with Spain to provide high gain antenna
  - Upgraded engineering camera design with color and improved resolution compared to MSL navcam/hazcams
  - Added EDL / Parachute Uplook Cameras
  - Augmented SHERLOC with infinite focus fine-scale color imager (based on MSL MAHLI)
  - RIMFAX formally selected for flight based on accommodation

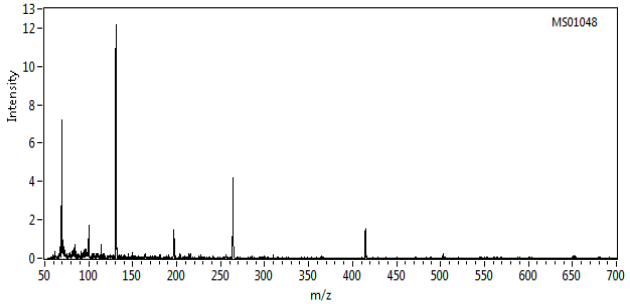


Project has made excellent progress to date, with plenty of challenging work still ahead

MOMA-MS Development

- **MOMA-MS Progress**
  - Qualification Simulator Model on track for delivery to TAS-I by August 2015 deadline
  - Flight Model build underway, on track for June 2016 delivery
  - First spectra from Flight Model Mass Spectrometer sensor hardware obtained during May vac test with lab electronics
  - Flight Model electronics ready for shipping to GSFC





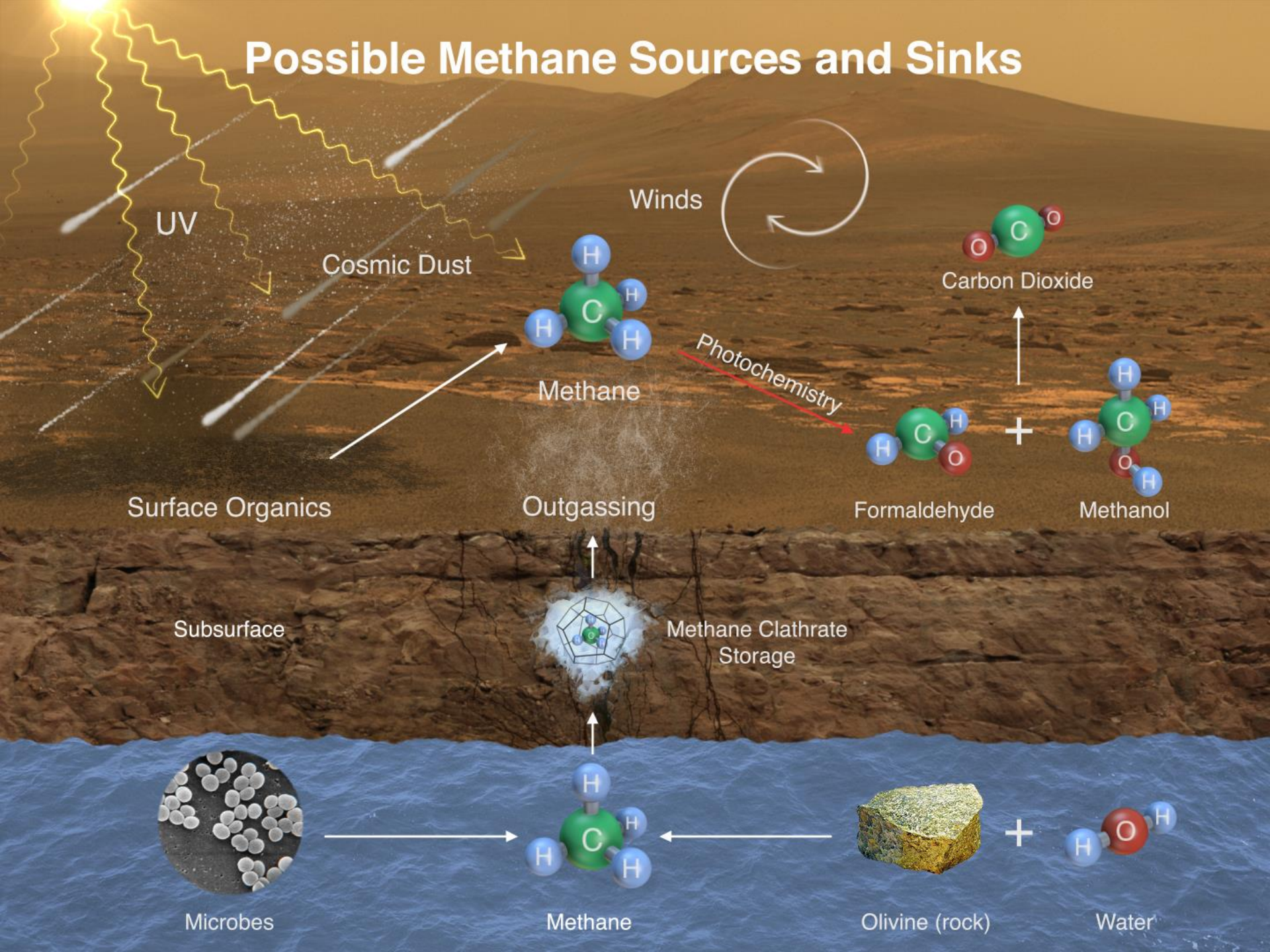
- **ExoMars 2018 Mission Progress**
  - System Delta PDR completed – May 2015

- **Challenges**
  - CNES delivery of MOMA-GC electronics and DLR flight laser significantly delayed due to lack of funding.
    - Awaiting decision from CNES regarding updated funding schedule.
    - ESA evaluating impact of descoping MOMA-GC science.
    - Programmatic Summit scheduled for June 15-16 @ ESTEC

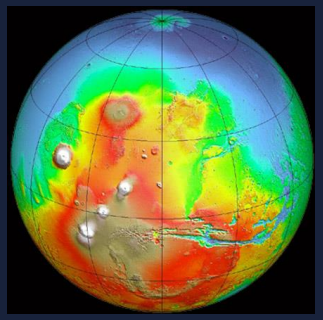
Mars Exploration Program Science

- Recent Status -

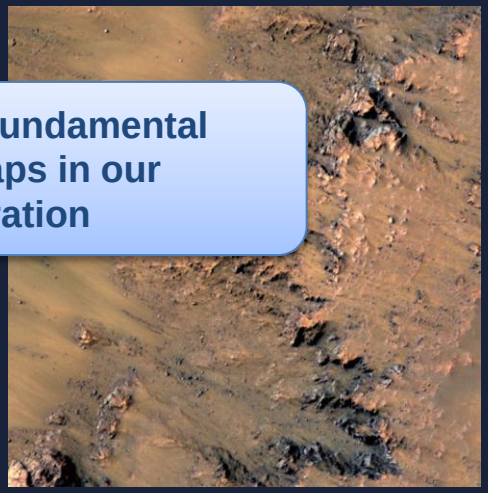
- **Science Increasing Understanding of the Martian System**
  - MAVEN observations revealed new phenomena
    - High-altitude day side dust cloud near terminator
    - Imaging Ultraviolet Spectrograph detected a broadly distributed diffuse aurora lasting 5-days
    - High-energy Solar Wind ions detected low in the atmosphere
  - MRO & Mars Express observations expanding understanding of CO2 in Martian environment
    - Larger volume of CO2 ice than previously considered, enough to double the martian atmosphere.
    - High altitude CO2 ice clouds measured
    - CO enrichment in topographic lows, residual from CO2 deplete air from which the seasonal cap condensed.
  - MRO found clay minerals probably lubricated landslides increasing their extent
  - ODY in new early-morning orbit has found water-ice clouds that had formed overnight in caldera near martian equator
  - OPPORTUNITY examining rock diversity on Cape Tribulation overlooking Marathon Valley
  - CURIOSITY traversed to the slopes of Mt. Sharp and is continuing ongoing analytical measurements
    - Curiosity measured variations in methane abundance on the traverse to Mt. Sharp
    - Curiosity conducted extensive exploration at Pahrump Hills covering a 10-m section of strata.
    - SAM instrument made the first detection of martian organics and nitrates

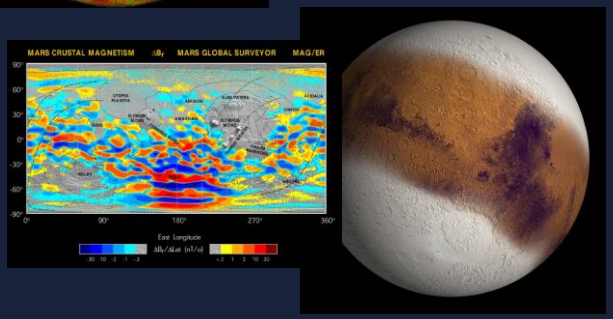

Possible Methane Sources and Sinks
UV
Cosmic Dust
Winds
Carbon Dioxide
Methane
Photochemistry
Surface Organics
Outgassing
Formaldehyde
Methanol
Subsurface
Methane Clathrate
Storage
Microbes
Methane
Olivine (rock)
Water

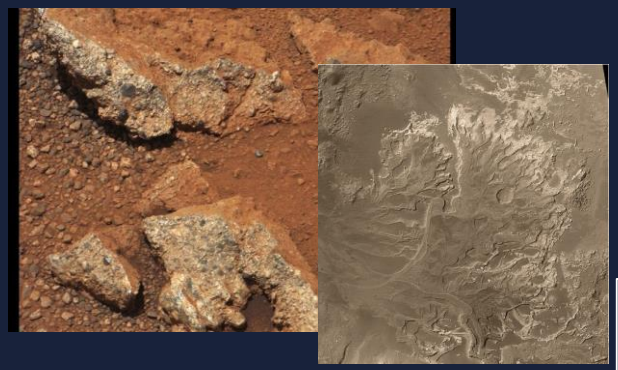
Science at Mars



Robotic missions have informed us on many of the fundamental mysteries of Mars, but there are still significant gaps in our understanding critical to future Human Exploration







Mars Environment

- *Geodesy – global topography*
- *Geography – surface mineralogy*
- *Atmosphere - profile, content, wind, dust*
- *Thermal variations*

- Learned:
  - Surface map
  - Weather – general trends
  - Magnetics – remnant field persists but protective field gone
  - Climate change evidence points to potential for remnant ice
- To Learn:
  - Open SKGs
  - Phobos/Deimos characteristics

Mars Resources

- *Surface ice – polar regions*
- *Frost build-up and sublimation*
- *Surface/subsurface flow – seasonal, consistent with brine, but how?*

- Learned:
  - Mars has extensive water ice resources
- To Learn:
  - Location & abundance of near subsurface ice, particularly at low latitudes
  - Cause and make-up of seasonal flows

Mars Habitability

- *Water once flowed and was stable*
- *Methane gas variability observed*
  - *Biological?*
  - *Geochemistry?*
- *Search for remnant traces of chemical building blocks of life underway with MSL and M2020*

- Learned:
  - Mars was habitable – all the ingredients necessary found in ancient Gale Crater
- To Learn:
  - Extraterrestrial Life?
    - Possible in the past – but did it emerge?
    - Could there be life today?
  - Sample return - life, toxicity, back contamination
  - Implications for human explorers

MARS

MEP Future Vision

- **Guiding Themes:** Serve exploration stakeholders through synergistic partnerships:
  - ✓ **Science**: Conduct highest priority science building on Decadal Survey priorities
    - Address keystone scientific questions about planetary habitability and the possibility of life beyond Earth
    - Be agile and robust, able to respond to discovery
  - ✓ **Inform and enable Human Mission design**: Provide knowledge, experience and technology to retire crew safety and operability risks, mature end-to-end systems engineering and continue building operational experience
    - Address key issues to build confidence in round-trip missions to/from Mars
    - Identify and characterize concentrated resources for potential ISRU exploitation
    - Respond to emerging needs
  - ✓ **Infrastructure**: Sustain and improve Mars telecommunications and surface reconnaissance infrastructure
  - ✓ **Technologies**: Capitalize on and validate advanced technical capabilities that inform conceptual designs for future human missions and enable end-to-end Earth/Mars missions with robotic precursors
- **Implementing Principles:** Timely and responsive approaches that provide affordable solutions:
  - ✓ Incremental steps composed of *Strategic* and *Competed* elements
  - ✓ Leverage and support collaboration through *integrated partnerships*

The 2020's would be a "**transition decade**" that sustains and increases Mars exploration capabilities by embracing new partnerships to leverage and amplify the science driven program elements in a manner that both advances science and promotes technology to help enable broader exploration initiatives across the Agency

MARS

Mars Exploration Program Science Activities

- Recent Initiatives Supporting Exploration -

- **Revision of MEPAG Goals Document nearing completion**
  - Brings the document up to date with respect to science advancements in all Goal areas
  - Increase cohesion and usability of the document, reflecting connections in current research
  - Prepare for upcoming activities (e.g., SAGs)
- **MEPAG conducting 2 Science Analysis Groups (SAGs)**
  - *Next Orbiter SAG (NEX-SAG) to analyze:*
    - Relevant scientific objectives derived from the revised MEPAG goals document
    - Needed measurement capabilities to locate *in situ* resources needed by future human missions
    - Synergies between the two sets of measurements
  - *Human Science Objectives SAG (HSO-SAG) to analyze:*
    - Our anticipated level of scientific knowledge at time of landing humans on Mars
    - What science should be advanced by humans based on the Mars surface?
      - Includes providing candidate landing sites for humans.
    - This is part of a larger joint HEOMD/SMD study looking at exploration locations on Mars.
- **Progress being made on Landing Site Observations**
  - MRO has satisfied >50% of all current landing site characterization requests for InSight, ExoMars, & Mars 2020 missions, progress slowed by no roll period, and now, solar conjunction
  - Mars 2020 *2nd* Landing Site Workshop – 1st week in August 2015

Ongoing Studies

How can these objectives be pursued?

ICE Working Group

ISRU & Civil Engineering

Co-Chairs: S. Hoffman, R. Mueller
Ex Officio: Bussey, Davis

HSO-SAG

Human Science Objectives

Co-Chairs: D. Beaty, P. Niles
Ex Officio: Bussey, Davis, Meyer

HLS²

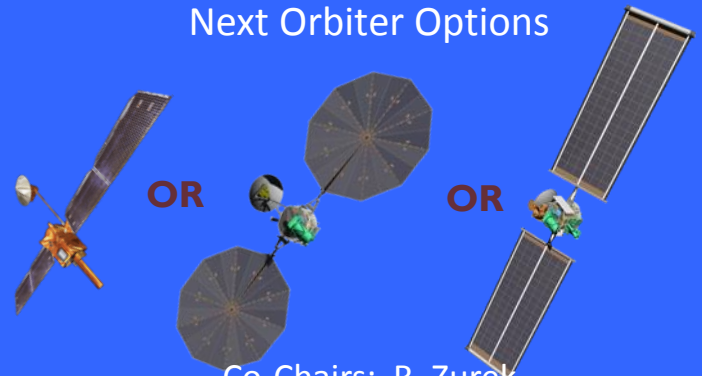
Human Landing Site Study
Coordinators:
Davis, Bussey, Meyer

What are the Base & Exploration Zone criteria? What & where are the resources needed?

Where & what should humans explore?

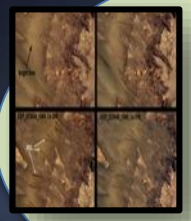
NEX-SAG

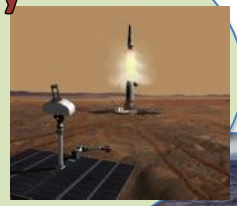
Next Orbiter Options



Co-Chairs: R. Zurek
Ex Officio: Meyer, Bussey

NRC Planetary Decadal Survey





MEPAG Goals

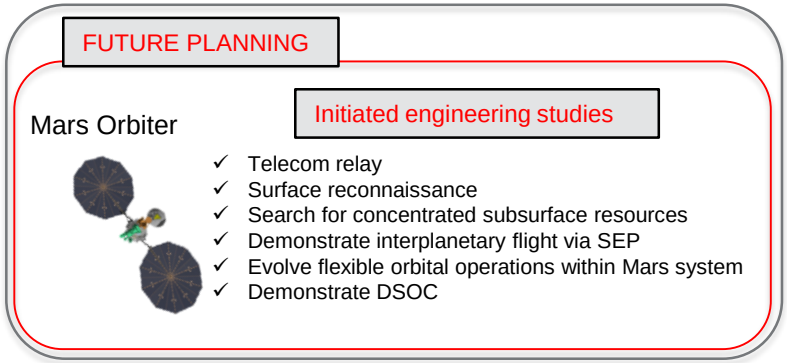
Science Objectives

Future Mission Planning

- **Multiple joint MEP/HEOMD/STMD trade studies underway**
  - Architecture Strategy
  - Human Landing Sites study
    - Human Science Objectives Science Analysis Group
    - In-Situ Resource Utilization (ISRU)/Civil Engineering Working Group
  - Next Orbiter Science Analysis Group
  - Mars Surface/EDL pathfinder mission study

- **Growing consensus emerging that science guided pathways provide natural precursor capability that could address early Exploration needs**
  - Collaborating on Science/Exploration synergies to define and address next step priorities

- **An Orbiter appears to be the next logical step for MEP missions**



MEP continues to be an essential enabler for NASA's *Journey to Mars*

Conclusion

- **MEP is healthy and improving**
  - Operational assets returning remarkable science
  - Budget supports current work
  - Mars 2020 development proceeding well
  - MOMA fabrication underway
- **Collaborating on Science/Exploration synergies to define and address next step priorities for future missions**